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Non-renormalization of the ‘chiral anomaly’ in interacting lattice Weyl semimetals

ABSTRACT: Weyl semimetals are 3D condensed matter systems characterized by a degenerate Fermi surface, consisting of a pair of ‘Weyl nodes’. Correspondingly, in the infrared limit, these systems behave effectively as Weyl fermions in 3+1 dimensions. We consider a class of interacting 3D lattice models for Weyl semimetals and prove that the quadratic response of the quasi-particle flow between the Weyl nodes, which is the condensed matter analogue of the chiral anomaly in QED4, is universal, that is, independent of the interaction strength and form. Universality, which is the counterpart of the Adler-Bardeen non-renormalization property of the chiral anomaly for the infrared emergent description, is proved to hold at a non-perturbative level, notwithstanding the presence of a lattice (in contrast with the original Adler-Bardeen theorem, which is perturbative and requires relativistic invariance to hold). The proof relies on constructive bounds for the Euclidean ground state correlation functions combined with lattice Ward Identities, and it is valid arbitrarily close to the critical point where the Weyl points merge and the relativistic description breaks down. Joint work with V. Mastropietro and M. Porta.